Space Weather Technical Forecast

Issued on Saturday, 30 December 2023 at 01:30 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of R1/Minor Radio Blackouts, mainly Days 1 (30 Dec) and 4 (02 Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with occasional C-class flares, the largest of which was an impulsive C9.8 flare from AR3533 at 29/0754 UTC. There are currently six sunspot regions on the visible disc. AR3533 in the northwest has been one of the more active regions, though is now relatively simple with an open structure and well separated lead and trailing spots of opposite polarity. AR3530, also in the northwest, is responsible for the most recent C6.6 flare at 29/2017 UTC. It is a more compact region than AR3533 and has continued to evolve over the past 24 hours. As it approaches the western limb, the viewing angle will preclude accurate assessment of the region. All the other regions appear simple and are either stable or in decline. Between 29/1000-1500 UTC a large filament on the northwest disc showed signs of instability and disruption, although no CME was observed on coronagraph imagery. No other CMEs observed during the period are considered to have Earth-directed components.

Solar Wind / Geomagnetic Activity: Solar wind speeds as observed by DSCOVR at L1 were initially at slightly elevated levels, around 420 km/s. Winds gradually declined through the morning to 360 km/s. There was a brief discontinuity around 29/1200 UTC with solar wind parameters perhaps supporting the idea of a weak CME arrival attributed to a prominence eruption on 25 Dec. Density was initially above average, peaking at 19 ppcc around 29/1100 UTC. Density then sharply declined around 29/1130 UTC, falling to average levels where it has largely remained. Total magnetic field strength, IMF, fluctuated between weak and moderate until 29/1130 UTC. Since then, it has been predominantly moderate. The north-south component, Bz, varied weakly throughout, fluctuating between -7/+8nT. Until 29/1130 UTC Bz was largely negative (southward oriented) but has since mainly been weakly positive (northward oriented). Phi angle was positive (away from the Sun) until around 29/1130 UTC at which point it switched to negative (towards the Sun).

Geomagnetic activity was Quiet through the period.

Energetic Particles / Solar Radiation: After an isolated peak at moderate levels at 29/0035 UTC, GOES16 high energy (greater than 10MeV) proton flux was at background. GOES16 high energy (greater than 2MeV) electron flux diurnally oscillated between background and moderate levels. The 24-hour fluence was below Active throughout and has been slowly declining. The 30/0000 UTC observation was 6.88e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is likely to continue, with a chance of Moderate activity. A couple of active regions are set to depart the disc during Days 1-2 (30-31 Dec) with new or returning regions due to rotate onto the disc by Day 4 (02 Jan).

Solar Wind / Geomagnetic Activity: No CMEs are expected to arrive at Earth during the forecast period. Connection to a high speed stream from CH86/- is anticipated either late on Day 2 (31 Dec) or early Day 3 (01 Jan), giving speeds of 450-550 km/s.

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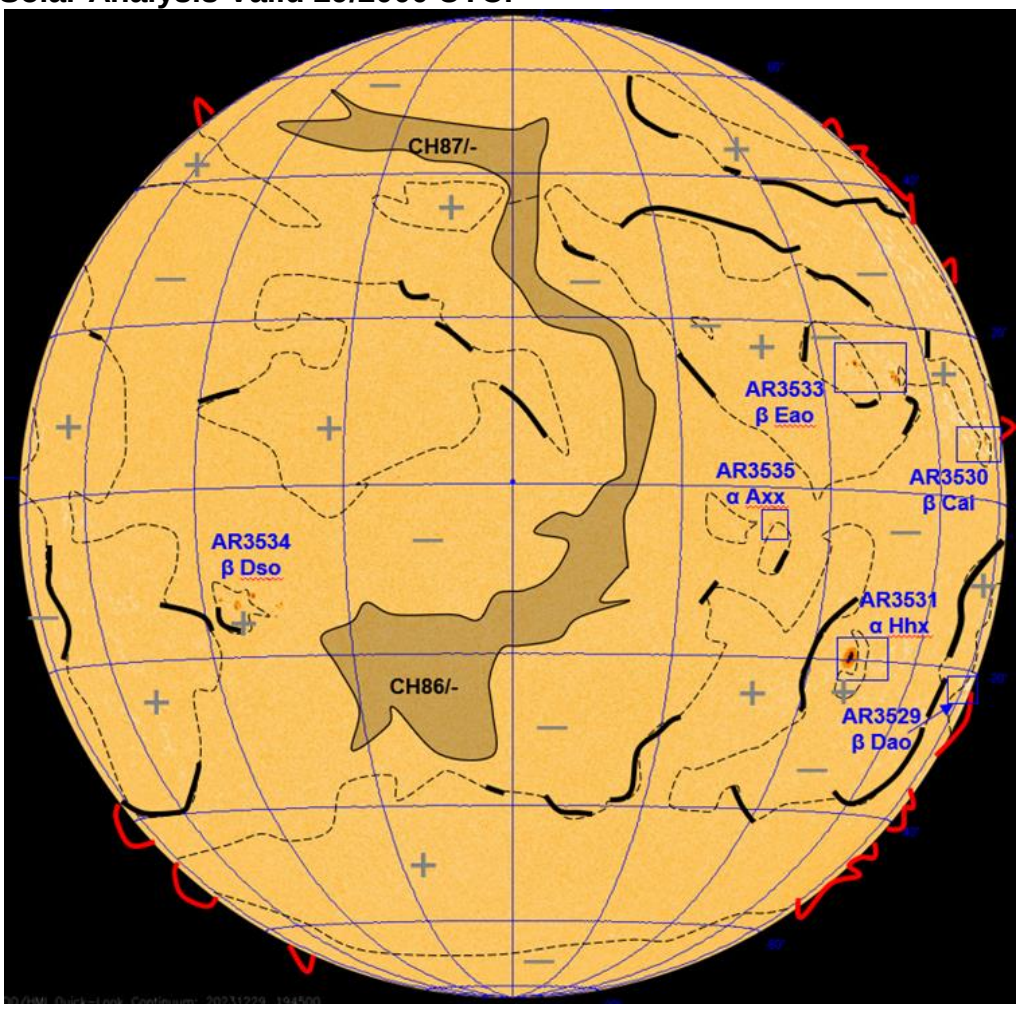
Geomagnetic activity is expected to be largely Quiet (Kp 0-2) through Days 1-2 (30-31 Dec). Activity is then expected to increase following connection to the HSS (or associated preceding CIR) with a risk of Active (Kp 4) intervals and a slight chance of reaching G1/Minor Geomagnetic Storm late Day 2 or early Day 3. Activity is then expected to decline to Quiet or Unsettled levels by Day 4 (Kp 0-3).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at background and likely to persist at this level. There is a very slight chance of reaching S1 given any notable flares from regions rotating toward the western limb. GOES16 high energy electron flux is likely to remain at moderate or background levels initially, perhaps with a slight rise toward the end of the forecast period following geomagnetic enhancement. Electron fluence levels will likely follow a similar trend, but with a very low risk of reaching the Active threshold on Day 4 (02 Jan).

Figure 1. Solar Analysis Valid 29/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:
No Earth-directed CMEs currently feature in the forecast.

Solar winds are expected to remain at slow-ambient levels through Day 1 (30 Dec) and much of

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Day 2 (31 Dec). The Earth is expected to connect to a high speed stream from CH86/- either late on Day 2 or early Day 3 (01 Jan). This coronal hole is a distinct and recurring feature, although is narrower on this rotation. On the last rotation speeds of around 500-600km/s were observed, with estimated speeds on this rotation estimated to be a more conservative 450-550 km/s. Enlil is considered to be giving good guidance with regards to the onset of the wind enhancement. SWPM is also considered to provide a reasonable steer with the trend of winds through the period, but is forecasting speeds that are 50-100 km/s higher than currently observed values. The duration of the enhancement from the coronal hole is uncertain due to the shape of the feature, but is expected to wane through Day 4 (02 Jan), with winds returning towards background levels.

Solar activity is expected to remain predominantly Quiet (Kp 0-2) through much of Days 1-2. The coronal hole high speed connection with a possible preceding CIR (co-rotating interaction region) gives a chance of Active (Kp 4) intervals late Day 2 or early Day 3, with a slight chance of an isolated G1/Minor Geomagnetic storm (Kp 5) interval. Geomagnetic responses are more muted close to the solstice, which is reflected in the lower probability than on the previous rotation. Activity is expected to return to Quiet or Unsettled (Kp 0-3) levels through Day 3 .

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	10	15	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

No CME's are currently expected.

Figure 2. Coronal hole comparison between last rotation (02-03 Dec) and this rotation (30-31 Dec).

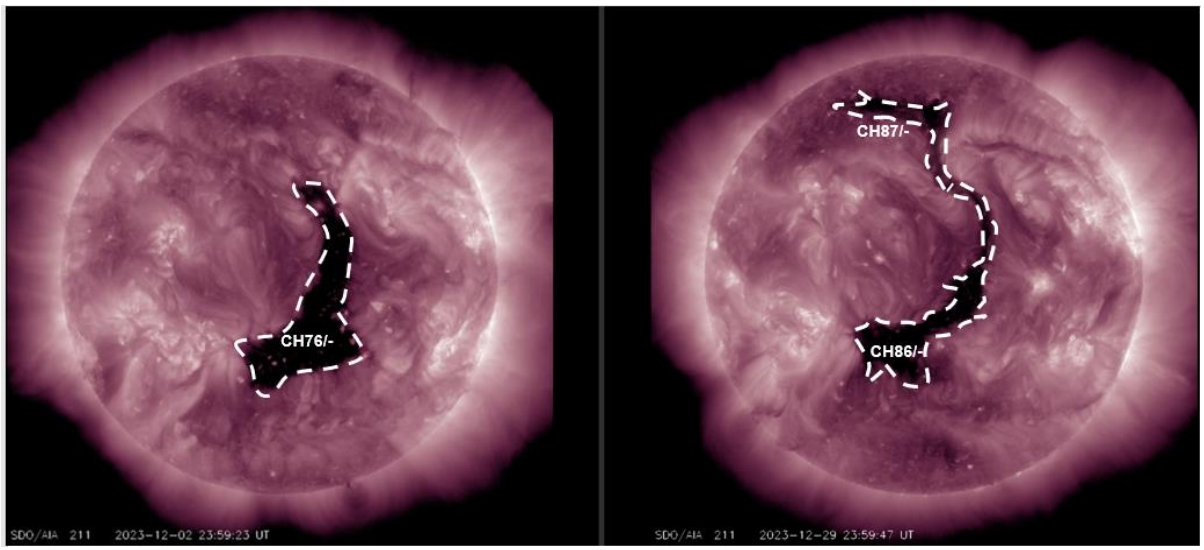

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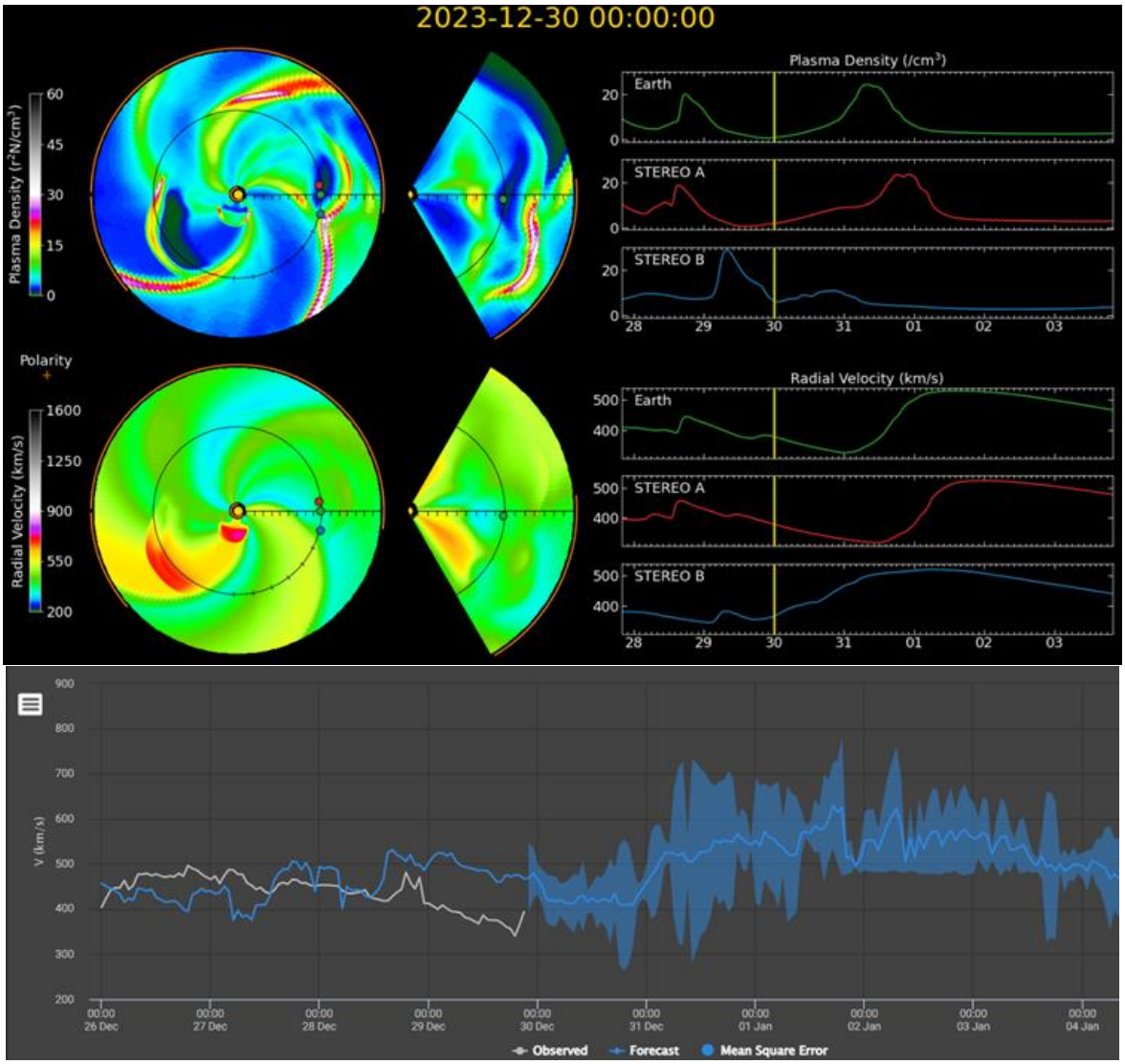
Figure 3. MOSWOC Enlil and SWPM showing current and forecast wind speeds noting the HSS connection later in the period.



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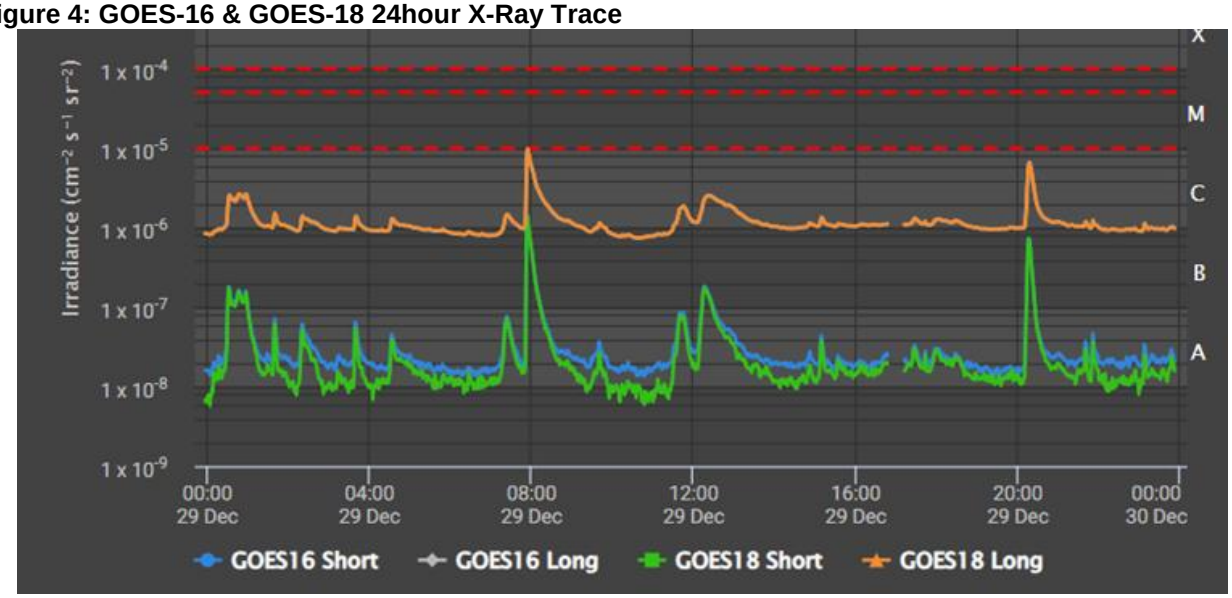
Radio Blackouts - X-Ray Flares:

There are currently six sunspot regions on the visible disc. AR3533 (Eao/Beta), in the northwest, is the most complex and one of the more active regions on the disc, though it appears relatively simple with an open structure and well defined lead and trailing portions of opposite polarity. AR3530, also in the northwest, was responsible for the recent C6.6 flare at 29/2017 UTC. AR3529 (Dao/Beta) in the southwest is a stable region that has largely rotated beyond the western limb, with only its trailing portion still visible. However, its previous classification of Eho/Beta may be more presentative of the region's complexity. All the other regions appear relatively simple and are either stable or in decline.

Solar activity is forecast to remain Low, with an ongoing chance of Moderate activity. AR3529 is due to depart the disc during Day 1 (30 Dec) with AR3530 following on Day 2 (31 Dec). Flare probabilities are expected to decline through Day 2 as result. Up to three sunspots regions are due to return or rotate onto the Earth-facing disc by Day 4 (02 Dec) with percentage flare probabilities increasing slightly to reflect the balance of outgoing and incoming sunspots.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	30	20	20	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 4: GOES-16 & GOES-18 24hour X-Ray Trace



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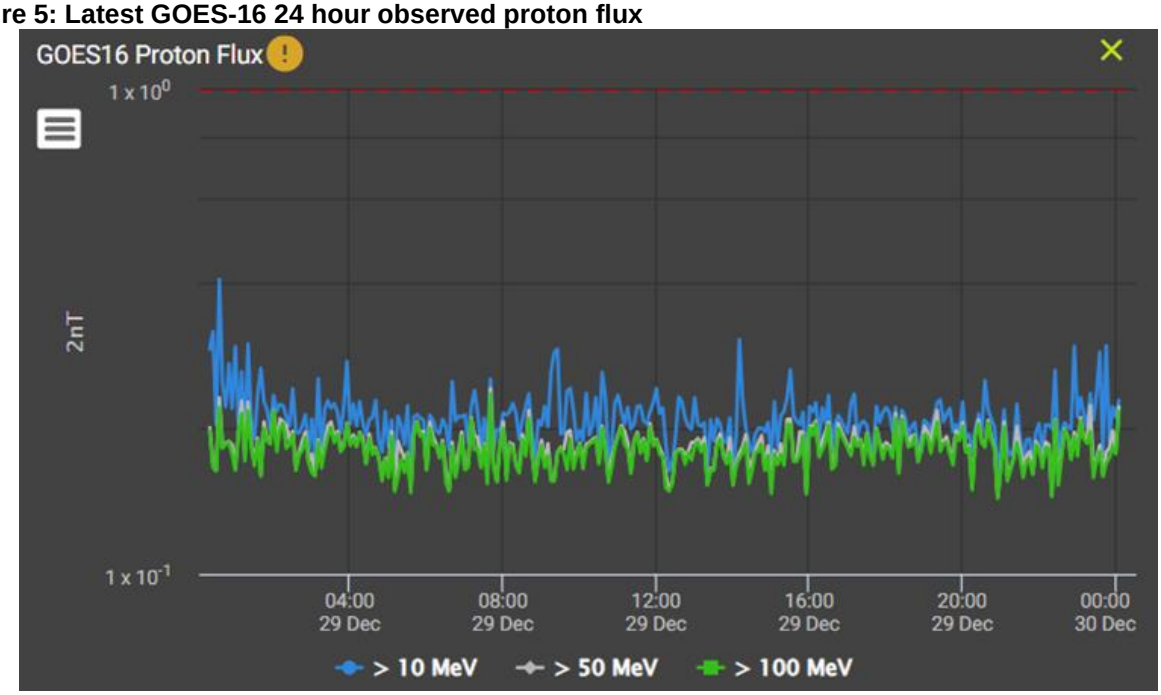
Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux has been largely at background levels, with only minor perturbations observed early in the period. There is a very slight chance of proton enhancement if any significantly energetic flare activity or Earth-directed CMEs were to be observed.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: Latest GOES-16 24 hour observed proton flux



High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has seen diurnal fluctuations between background and moderate levels. In the absence of any enhancement, this pattern is expected to continue. Although there may be a slight suppression of electron flux levels following interaction with a high speed stream late Day 2 (31 Dec) or Day 3 (01 Jan), a more pronounced increase in electron flux is then possible Days 3-4 (01-02 Jan).

Electron fluence is expected to show a steady trend, remaining well below the Active (1e8 integrated pfu) threshold. Electron fluence levels may recover slightly towards the end of the period, but there is only a very slight chance of reaching Active level. REFM is projecting levels to remain well below Active, with forecast values currently considered good guidance.

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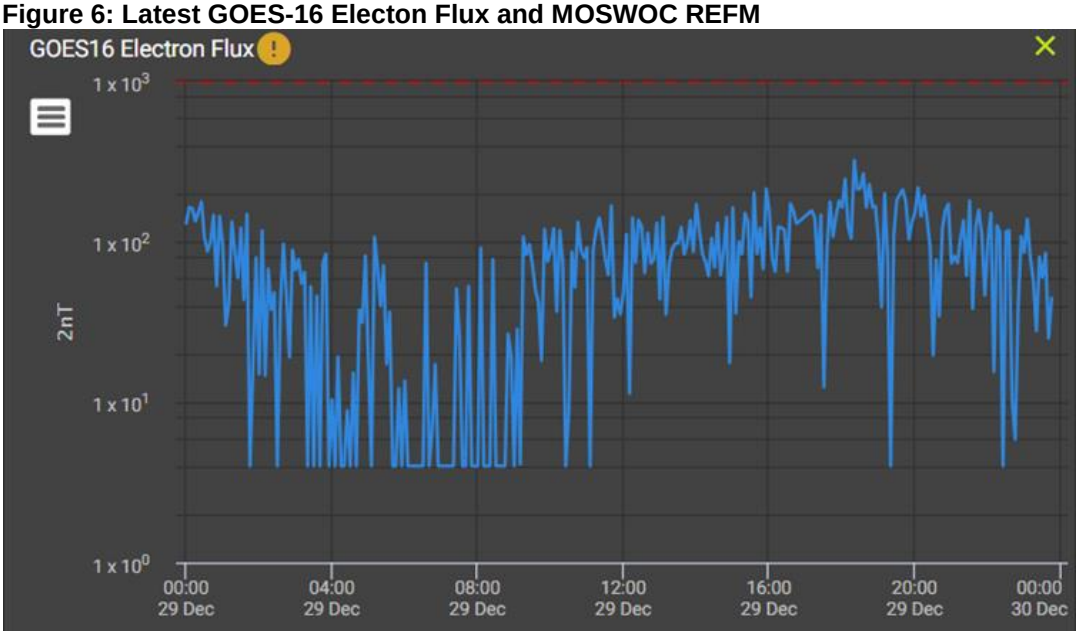
GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 6: Latest GOES-16 Electon Flux and MOSWOC REFM



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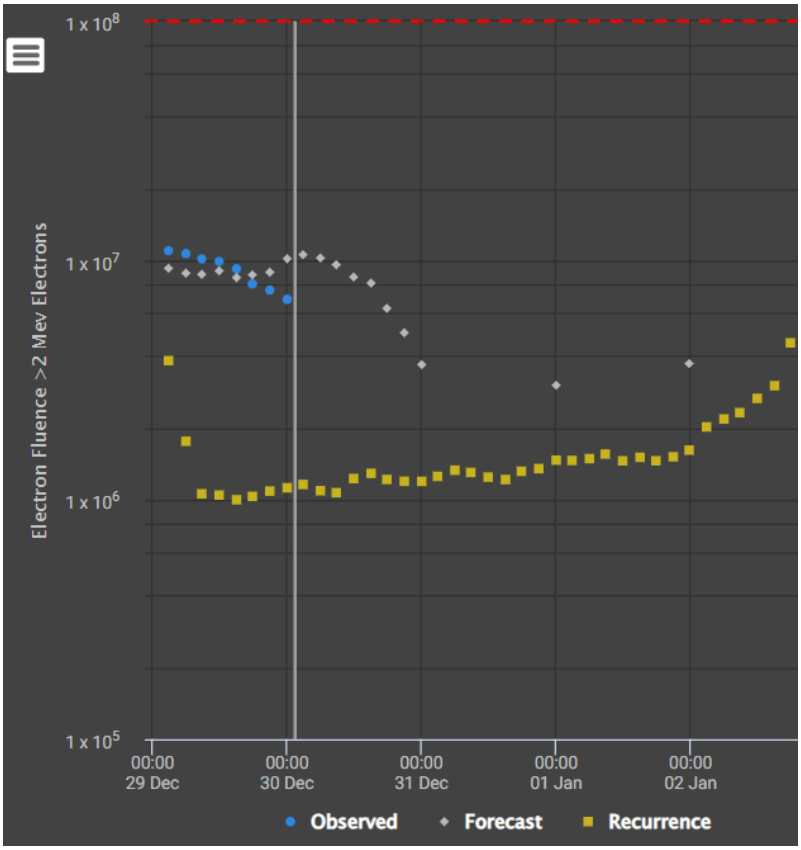

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